APPENDIX G

CALCULATIONS FOR CALCULATED VS. MEASURED DYE DILUTIONS FOR EACH CRUISE SHIP.

M/S Majesty

Majesty calculated dye concentration in tank
Volume of graywater in tank (V_{gw}) - 113 m^3 X 1000L/m^3 =113,000L graywater/blackwater
Volume of dye (V_{dy}) - 30gal . dye = 113.6L
Vgw + Vdy = 113,114
Wt. Of active ingredient in 30 gal, dye - 22.6 kg active ingredient/114 L dye
therefore Concentration of active ingredient in tank (C_{tc}) = 22.6kg dy/113,114 L gw or 22600 g dy/113,114 L gw
Calculated Tank Dye Concentration (C_{tc})= 0.1998 g dy/L
Measured Tank Dye Concentration (C_{tm}) from Appendix F -Table F- 2 = 0.13512 g dy/L

Amount of dye not discharged (left in the tank)
Of the 113,114 L of Dye in the tank at the initiation of pumping 7000 L (7 m^3) were not pumped overboard.
0.1998 g dy/L (conc dye in tank)= Xg/7000L where X=amount of dye not discharged
0.1998 g dy/L* 7000 L = X_g = **1398.6 g dy**

Distance traveled D_x in 57 min at a speed of 17.4 kts.
D_X/57=17.4/60
Dx = 57 min. * 17.4 kts./60 min.
Dx = 991.8 min kts./60 min
Dx = 16.5 nmi traveled

Majesty calculated initial concentration based on length (ship pumping specifications - Table 2), width, and depth of initial plume transect.
Plume dimensions and volume
1 nmi = 1852 m
1852 x 16.5 = 30,558 m
Plume width = width of plume at first transect = 66m
Depth of plume ~ 18 m
Volume of plume~ 66m * 18m * 30,558= 36,302,904 m^3 * 1000L/m^3 = 36,302,904,000 L

Calculated concentration of dye in plume (C_{pc}) = g/L
C_{pc} = 22600g – X_g from above/36,302,904,000 = 22600g –1399g/36,302,904,000 L= 21201/36,302,904,000 L
C_{pc} = 5.84 * 10(-7) g/L =
Majesty **Initial Calculated Dye Concentration (C_{pc}) = 0.584 ug/L**

Majesty **- Calculated Dilution = Tank Concentration/Seawater Concentration**
0.1998g/0.584ug/L = 0.1998g/L/.000000584g/L =
Majesty **Calculated Dilution = 342,123:1**

Majesty **- Average Initial Measured Dye Concentration (dye 2) in Plume = 0.35 µg/L** (First Transect)
Majesty **- Measured Dilution = Tank Concentration/Seawater Concentration**
0.13512g/L/0.35ug/L = 0.13512g/L/.00000035g/L =
Majesty **Measured Dilution 386,057:1**

M/S Explorer

Explorer calculated dye concentration in tank

Volume of blackwater and dye in tank (V_{bw+dy}) - 18.3 m^3 *1000L/m^3 =18,300L gw+dye
Volume of dye (V_{dy}) - 35 gal. dye = 133 L (already measured as part of the gray water volume)
Wt. Of active ingredient in 35 gal (133 L) dye - 26.4 kg active ingredient/133 L dye
26.4kg dy/18300 L gw+dye therefore 26400 g dy/18300 L gw+dye
Calculated Tank Dye Concentration =1.443 g/L
Measured Tank Dye Concentration = 1.002 g/L

Amount of dye not discharged (left in the tank)

Of the 18300 L of Dye in the tank at the initiation of pumping 1200 L (1.2 m^3) were not pumped overboard.
1.443 g dy/L (conc dye in tank)= Xg/1200 L where X=amount of dye not discharged
1.443 g dy/L* 1200 L = X $_g$ = **1731 g dy**

Distance traveled (D_X) in 18 min at a speed of 19 kts.

D_X /18=19/60
D_X =18 min.*19 kts./60 min.
D_X = 342 minkts./60 min
D_X = 5.7 nmi traveled

Explorer calculated initial concentration based on length (ship pumping specifications - Table 2), width, and depth of initial plume transect.
Plume dimensions and volume

1 nmi = 1852 m
1852 x 5.7 nmi =10556
Plume width = width of plume at first transect = 147m
Depth of plume ~ 10 m
Volume of plume~ 147m * 10m * 10556 = 15,517,320 m^3 * 1000L/ m^3 = 15,517,320,000 L

Calculated concentration of dye in plume (C_{pc}) = g/L

C_{pc} = 26400g – X_g dy from above/15,517,320,000L = 26400g –1731g dy/15,517,320,000L= 24,669g dy/15,517,320,000L
1.59 * 10(-6)g/L =
Explorer - **Calculated Initial Dye Concentration = 1.59 ug/L**

Explorer- **Calculated Dilution = Tank Concentration/Seawater Concentration**
1.443g/L/1.59ug/L =1.443g/L.00000159g/L =
Explorer **Calculated Dilution = 907,547:1**

Explorer - **Average Initial Measured Dye Concentration (Dye 2) in Plume = 5.13 ug/L** (First Transect)
Explorer - **Measured Dilution = Tank Concentration/Seawater Concentration**
1.002g/5.13ug/L = 1.002g/.00000513g/L =
Explorer **Measured Dilution = 195,321:1**

M/S Paradise

Paradise calculated dye concentration in tank
Volume of graywater in tank (V_{gw}) - 108 m^3 * 1000L/ m^3 = 108,000L gw+dye
Volume of dye (V_{dy}) 35gal . = 133 L dye
Vgw + Vdy = 108,133
Wt. Of active ingredient in 35 gal (133 L) dye - 26.4 kg active ingredient/133 L dye
26.4 kg dye/108,133L gw+dy therefore 26400 g dy/108,133 L gw+dy
Calculated Tank Dye Concentration = 0.244 g/L
Measured Tank Dye Concentration = 0.2704 (from Table F-2 in Appendix F)

Amount of dye not discharged (left in the tank)
Of the 108,133 L (108.133 m^3)of dye + graywater in the tank at initiation of pumping 40,000 L (40 m^3) were not pumped overboard (pumping lasted for 30 min).
0.244 g/L (conc dye in tank) = Xg/40,000L where Xg = amount of dye not discharged
0.244 g/L * 40,000L =Xg therefore Xg = 9765g

Distance traveled (D_X) in 30 min at a speed of 15 kts.
D_X /30=15/60
D_X =30 min * 15 kts./60 min.
D_X = 450 min kts./60 min
D_X = 7.5 nmi traveled

Paradise calculated initial plume concentration based on length (ship pumping specifications - Table 2), width, and depth of initial plume transect.
Plume dimensions and volume
1 nmi = 1852 m/nmi
1852 * 7.5=13,890 m
Plume width = width of plume at first transect = 182 m
Depth of plume ~ 18 m
Volume of plume~ 182m * 18m * 13890= 45,503,640 m^3 * 1000L/m^3 = 45,503,640,000 L

Calculated concentration of dye in plume (C_{pc}) = g/L
26400 g - Xg from above/45,503,640,000 L = 26400g –9765g/45,503,640,000 L =
16635/45,503,640,000 L = 3.656 *10(-7) g/L =
Paradise Initial Calculated Dye Concentration = 0.3656 ug/L

Paradise Calculated Dilution = Tank Concentration/Seawater Concentration
0.244g/L/0.366ug/L = 0.244g/L/.000000366g/L =
Paradise Calculated Dilution =666,667:1

Paradise - Average Initial Measured Dye Concentration (Dye 2) in Plume = 0.42 ug/L (First Transect)
Paradise - Measured Dilution = Tank Concentration/Seawater Concentration
0.2704g/L/0.42ug/L = 0.2704g/L/.00000042g/L =
Paradise Measured Dilution = 643,809:1

M/S Fascination

Fascination calculated concentration in tank
Volume of graywater in tank (V_{gw}) - 27m^3 * 1000L/m^3 =27,000L gw
Volume of dye (V_{dy}) 36gal . = 137 L dye
Vgw + Vdy = 27,137
Wt. Of active dye ingredient in 36 gal, 27.1 kg dye
27.1 kg dye/27,137L gw+dy therefore 27100 g dy/27,137 L gw+dy
Calculated Tank Dye Concentration = 0.999 g/L
Measured Tank Dye Concentration = 0.9806 (from Table F-2 in Appendix F)

Amount of dye not discharged (left in the tank)
Of the 27,137 L (108.1370m^3) of Dye in the tank at initiation of pumping
3000 L (3 m^3) were not pumped overboard. (pumping lasted for 30 min).
0.999 g/L (conc dye in tank)= Xg/3,000L where Xg=amount of dye not discharged
0.999g/L * 3,000L = Xg therefore Xg = 2997g

Distance traveled in 20 min at a speed of 9.1 kts.
X/20=9.1/60
X =20 min * 9.1 kts./60 min.
X= 182 min kts./60 min
X = 3.03 nmi traveled

FASCINATION CALCULATED INITIAL CONCENTRATION BASED ON LENGTH (SHIP PUMPING SPECIFICATIONS - TABLE 2), WIDTH, AND DEPTH OF INITIAL PLUME TRANSECT.
Plume Dimensions and Volume
1852 * 3.03=5612 m
Plume width = width of plume at first transect = 88m
Depth of plume ~ 12.5 m
Volume of plume~ 88m x 12.5m x 5612= 6,172,100 m^3 * 1000L/m^3 = 6,172,100,000 L

Calculated concentration of dye in plume (C_{pc}) = g/L
27100 g - Xg from above/6,172,100,000 L = 27100g dye –2997g/6,172,100,000 L =
24103g dye/6,172,100,000 L = 3.91 * 10(-6) g/L =
Initial Calculated Dye Concentration = 3.91 ug/L

Fascination - **Calculated Dilution = Tank Concentration/Seawater Concentration**
0.999g/3.91ug = 0.999g/.00000391g/L =
Fascination **Calculated Dilution = 255,499:1**

Fascination **-Average Measured Dye Concentration (Dye 2) in Plume= 3.4 ug/L** (First Transect)
Fascination Measured Dilution = Tank Concentration/Seawater Concentration
0.9806g/L/3.4ug/L = 0.9806g/L/.0000034g/L =
Fascination **Measured Dilution = 288,411:1**